EFFECT OF PROTECTIVE COATINGS ON THE STRESS-CORROSION PROPERTIES OF SUPERSONIC-TRANSPORT SKIN MATERIALS

NINTH QUARTERLY STATUS REPORT
to
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
For the Period Between 1 December, 1964 & 28 February, 1965

Contract No. NASr-117

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REPORT ON

EFFECT OF PROTECTIVE COATINGS ON THE STRESS-CORROSION PROPERTIES OF SUPERSONIC-TRANSPORT SKIN MATERIALS

INTRODUCTION

This report summarizes the progress made during the third quarter of the third year of the project being performed by Southern Research Institute under Contract No. NASr-117. This quarter consists of the period between 1 December, 1964, and 28 February, 1965.

The purpose of this research project is to determine whether selected coatings will protect metal substrates from stress-corrosion. These data will provide needed additional information on the feasibility of using commercially available protective coatings to prevent corrosion of the skins of supersonic-transport aircraft. The coatings and substrates to be evaluated were chosen from the results of earlier work on this contract (1, 2)[1].

Pertinent background information and a detailed description of the specimen preparation along with the general evaluation procedure were presented in earlier progress reports and will not be repeated here. Described briefly, the program consists of various exposures applied to self-loading type specimens constructed as shown in Figure 1. The substrates, coatings, exposure conditions, and evaluation methods are charted in Figure 2.

WORK PERFORMED

Specimen Construction

Construction of the self-loading type specimens from each of the three substrate materials was completed during the first week of this report period. The specimens were then immediately shipped to the coating suppliers for application of their coatings. The distribution of the specimens to the coating suppliers is presented in Table 1.

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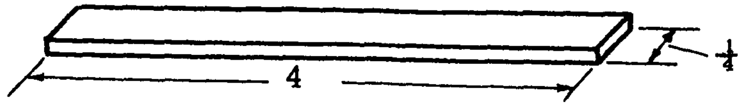
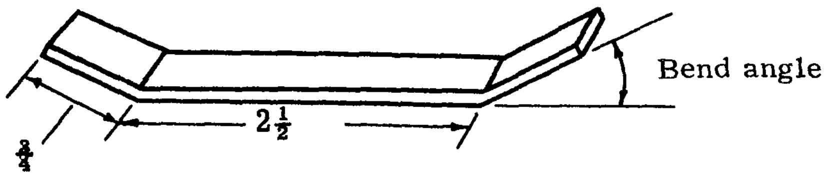
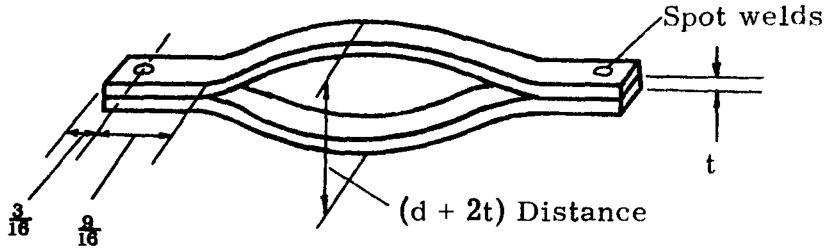
[1] The numbers in parentheses refer to the bibliography at the end of the report.



(a) Machined strip.

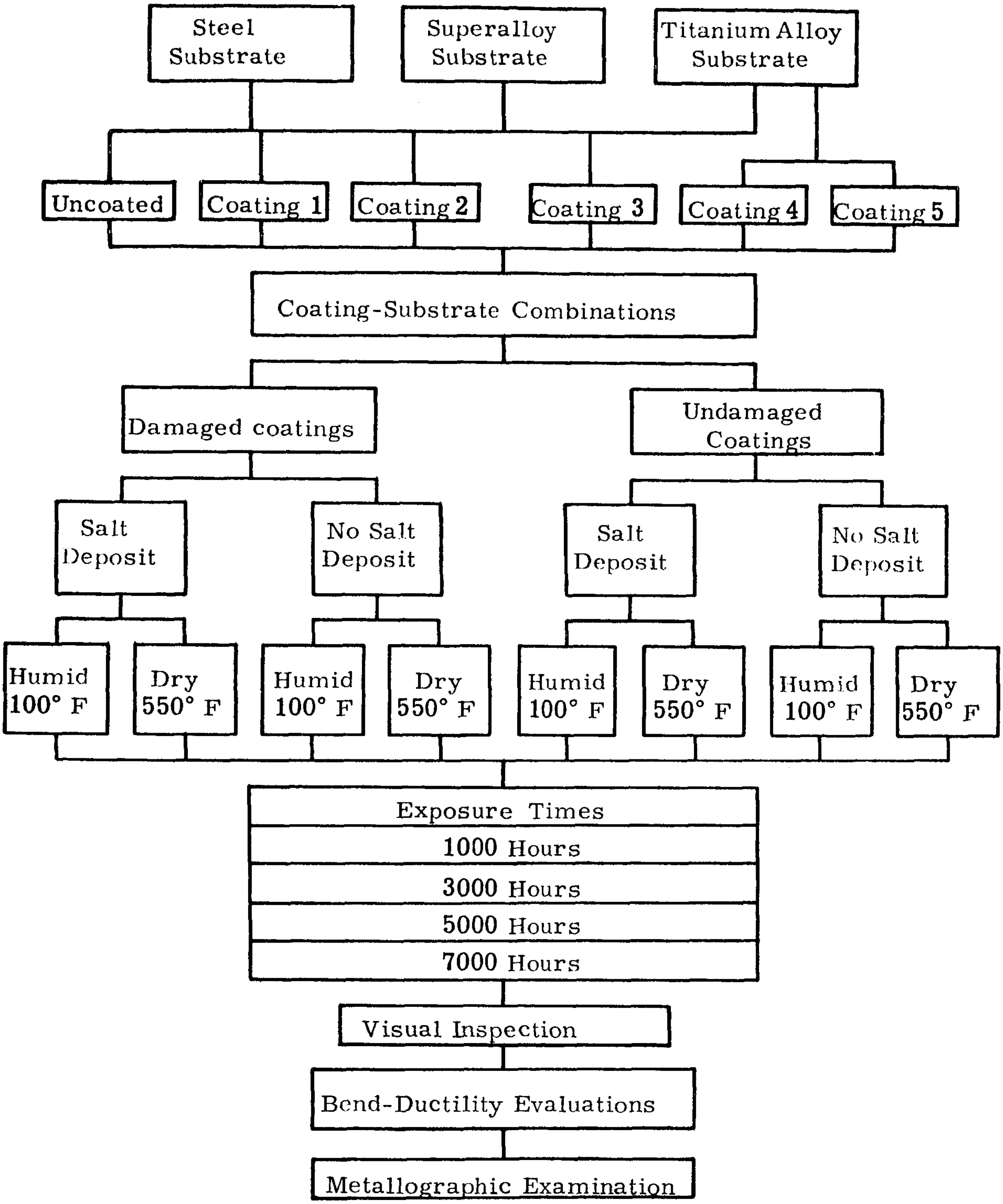


(b) Strip with ends bent.



(c) Completed specimen.

Figure 1. Construction of the self-stressed specimen. (All dimensions are in inches).



Coating 1 - Aluminum-Modified Silicone
Coating 2 - Catalytically Cured Silicone
Coating 3 - Zinc in Silicate vehicle
Coating 4 - Electrophoretically Deposited Aluminum
Coating 5 - Flame-Sprayed Aluminum

Figure 2. Flow Sheet of Experimental Conditions

Table I. Distribution of Specimens to Coating Suppliers

Substrate Material	Number of Specimens	Coating Supplier	Coating
1. AM350	68	Dow Corning Corp.	Aluminum-Modified Silicone
	69	Humble Oil Co.	Zinc in Silicate Vehicle
	69	Air Force Mat. Lab.	Catalytically Cured Silicone
2. Rene 41	90	Dow Corning Corp.	Aluminum-Modified Silicone
	90	Humble Oil Co.	Zinc in Silicate Vehicle
	89	Air Force Mat. Lab.	Catalytically Cured Silicone
3. Titanium	73	Dow Corning Corp.	Aluminum-Modified Silicone
	72	Humble Oil Co.	Zinc in Silicate Vehicle
	73	Air Force Mat. Lab	Catalytically Cured Silicone
	26	Metco, Inc.	Flame-Sprayed Aluminum
	59[a]	BISRA	Elphal

a. Specimens were made from panels of this coating-substrate combination which were left over from last year's work.

The specimens have been returned, and none of the coatings were damaged during shipment. All coatings, with the exception of flame-sprayed aluminum, were applied to the entire surface of the specimens. The flame-sprayed aluminum coating supplier could not apply a uniform coating to the inner (concave) surfaces of the specimens' bowed members and consequently left them bare. The supplier did, however, apply a uniform coating to the outside (convex) surfaces of the specimens.

Fixtures

It was necessary to construct fixtures capable of supporting appropriate groups of each coating-substrate combination during exposure to the elevated-temperature and the warm humid conditions.

A metal stand made from structural aluminum angles, 1/8 in. x 3/4 in. x 3/4 in., was constructed to withstand the elevated-temperature exposures. This stand supported eight sliding frames that hold the specimens and make it convenient to remove the completed short-duration specimens without interrupting those specimens requiring longer exposures. The sliding frames were constructed from 1/8-in.-diameter welding rods joined together by spot welding.

Four rectangular plastic waste baskets were fitted for use as humidity chambers by means of a framework designed to support an appropriate number of specimens for a particular exposure interval. The framework consisted of two wood planks contoured to stand vertically in the containers, and drilled with holes through which the 1/8-in.-diameter stainless-steel welding rods that supported the specimens could be inserted.

A fixture with which we damaged representative specimens from each coating-substrate combination by a transverse and longitudinal scratch intersecting at the location of maximum stress was also constructed. The fixture consisted of a bench-type drill-press stand to which a Rockwell diamond penetrator and an Ames 102 dial gage were attached. The Rockwell penetrator was anchored in a copper sleeve, which was fixed to the movable shaft of the drill press. By means of the drill-press crank arm, the movable shaft and the penetrator could be adjusted to any desired vertical position. A stationary table was placed under the penetrator for support of the specimen. As a specimen holder, we employed one-half of the welding fixture described in previous progress reports. It was ideally contoured to accommodate the bowed portion of each specimen and contained two locator stops at one end which assured repetitive alignment for all specimens. The operation of this fixture is described later in the report.

Exposures

Upon receipt from the coating suppliers, all specimens were identified and appropriate groups of specimens were conditioned for exposure by scratch damage and salt deposition. The specimens were then mounted in the racks and appropriate groups placed in the test environments—dry 550° F and humid 100° F.

PROCEDURES

Identification

An alternating letter-number arrangement consisting of four letters and three numbers was assigned to each specimen as a means of identification. The illustration of the arrangement, presented in Figure 3, indicates the proper letter-number sequence and also reveals what each letter and number represents. The letter-number sequences were scribed on tags, which were secured at a tab end of the specimens. Metal (Monel) tags were used for the high-temperature specimens while paper merchandising-type tags were used for those specimens requiring humid exposures.

Application of Scratch Damage

Appropriate groups of both bare and coated specimens from each substrate material were scratch damaged by forcing the specimens under the Rockwell diamond penetrator described above. The vertical position of the penetrator for each of the substrate materials was determined by placing a bare specimen on the specimen holder with its (d + 2t) distance (refer to Figure 1 c) in the vertical direction. The specimen-holder assembly was then positioned under the penetrator through the use of a guide rail mounted on the table so that the penetrator when lowered would touch a bowed member at its maximum point of stress. As the penetrator was lowered by the crank arm, the dial gage was activated by bearing against a surface mounted on the stationary table. When the penetrator touched the specimen, the dial gage was manually set to zero. The specimen-holder assembly was then removed and the penetrator was lowered 0.020 or 0.025 in. from the zero setting and locked into position. The specimen-holder assembly was then re-positioned along the guide rail and was forced forward under the penetrator, causing a scratch to extend transversely across the member's point of maximum stress. The orientation of the specimen with respect to the penetrator was then changed 90° and the operation repeated in order to produce a

2. Coating Designation 4. Salt Exposure 5. Temperature Exposure

1. Substrate Designation → X 8 X 8 X 8 X ← 7. Consecutive Replicates

3. Damage Designation 6. Exposure Duration

Example: A 0 D 1 L 1 A

1. A = AM350, R = Rene 41, T = Titanium.
2. 0 = Bare, 1 = Aluminum-Modified Silicone, 2 = Catalytically Cured Silicone, 3 = Zinc in Silicate Vehicle, 4 = Electrophoretically Deposited and Rolled Aluminum, and 5 = Flame-sprayed Aluminum.
3. D = Damaged, U = Undamaged.
4. 1 = No Salt, 2 = Salt Deposit.
5. L = 100° F Humid Exposure, H = 550° F Dry Exposure.
6. 1 = 1,000 Hours, 3 = 3,000 Hours, 5 = 5,000 Hours, and 7 = 7,000 Hours.
7. A = First Specimen, B = Second Specimen, C = Third Specimen.

Figure 3. Specimen Identification System

longitudinal scratch intersecting the transverse scratch. Once the penetrator was set and locked into position for a particular substrate, all specimens were scratched with the same setting. The 0.020-in. setting was used for all substrates except the substrate coated with catalytically cured silicone. This coating-substrate combination required a 0.025-in. penetrator setting to insure penetration into the substrate. Since the settings were determined on bare substrates, the scratches extended through the coating and into the substrates of the coated specimens. The scratch depths into the substrate are estimated to be approximately 0.005 in. but, because of slight non-uniformity in geometry from specimen to specimen, the scratch depths vary to some extent.

Application of Salt Deposits

Salt was applied to the appropriate specimens by momentarily hand dipping each specimen into a 20% aqueous salt solution at room temperature. Each specimen was held horizontally by the tab ends with its (d + 2t) distance (refer to Figure 1 c) extending vertically and was lowered into the salt solution so that only one member was wetted at a time. We allowed the solution to contact the bowed member only on its convex side and at an area near the point of maximum stress. The specimen with its wetted member was then placed on a rack over a hot plate and thoroughly dried. After drying, this same procedure was repeated for the other bowed member.

Environmental Exposures

All specimens to receive the high-temperature exposure were loaded on the metal frames, two of which were allotted for each exposure interval. The specimens were arranged horizontally in two parallel rows on each frame with each specimen supported at its tab ends. In order to accommodate the large number of specimens within the limited furnace space, the specimens were positioned on the frames with their (d + 2t) distances (refer to Figure 1 c) extending vertically. Only enough space space between specimens to prevent contact was allowed. Of the two rows on each frame, one row contained salt-deposited specimens and the other contained unsalted specimens. The loaded frames were placed in the aluminum stand in such a manner that the salt deposited and unsalted specimens were in opposite vertical rows. These precautions were taken to prevent any dislodged salt grains from falling on unsalted specimens. The loaded stand was placed in a circulating-air electric oven set at 550° F.

The specimens for low-temperature exposure were placed on the supporting rods in each container with their (d + 2t) distances(refer to Figure 1 c) extending horizontally. Each specimen was supported near the outer ends of its bowed gage section. By positioning the specimen in this manner, both bowed members were on the same level and would thus share the same conditions during exposure. Vertical positioning of the specimen's (d + 2t) distance would allow any condensate that might drip from the top member to collect on the bottom member and produce unequal conditions between the two.

In each container the salt-deposited specimens were placed on the lower level supporting rods to insure against any transference of dripped salt to the unsalted specimens. Distilled water was added to the bottom of each container to a depth of 1/2 in. The top of each container was sealed with a thin, transparent plastic film and then all containers were placed in a room thermostatically controlled at 95° F.

FUTURE WORK

During the next quarter, we shall design and construct a fixture to support the specimens for the bend-ductility evaluations. Specimens from the 1,000-hour-exposure interval, which ends on 31 March, will be evaluated during the next quarter. Bend-ductility evaluations will be performed on all of these specimens and metallographic examinations will be made on selected specimens.

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